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METHOD OF WELDING A SKIRT TO A CYLINDRICAL VESSEL

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FIG. 1

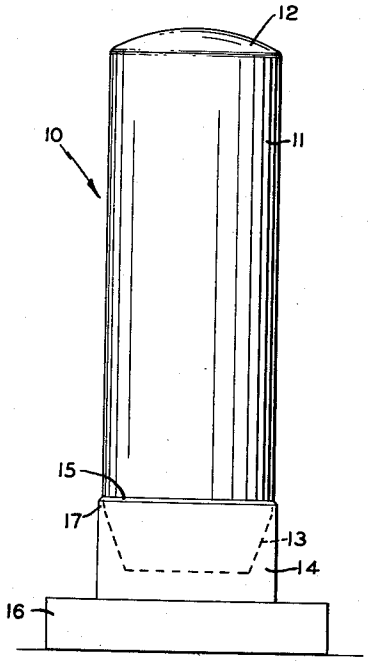
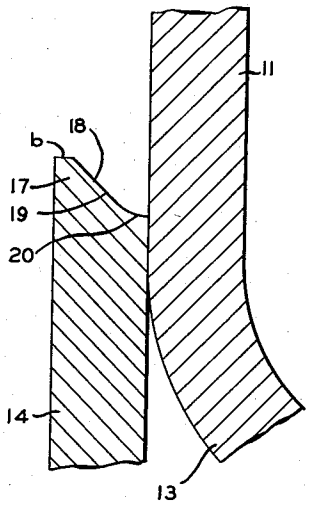


FIG. 2



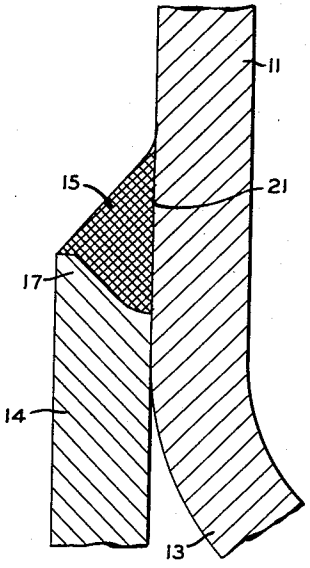


FIG. 3

INVENTOR.
NICHOLAS A. WEIL

BY S. H. Palmer
V. T. Davis
ATTORNEYS

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METHOD OF WELDING A SKIRT TO A CYLINDRICAL VESSEL

Nicholas A. Weil, Middle Village, N.Y., assignor to The M. W. Kellogg Company, Jersey City, N.J., a corporation of Delaware

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This invention relates in general to fusion welding and in particular to the provision of a welded joint between the shell of a vessel and a support member which connects the vessel to its foundation.

It is usual to support large, heavy vessel shells on skirts that are attached to, and carried on, foundations suitable to support the vessel in the intended use. It is also usual to unite the vessel shells to the supporting skirts by fusion welds that are deposited circumferentially as fillet welds around the vessel shells. These fillet welds are deposited on the shoulder defined by the horizontal end surface of the skirt and the contiguous vertical surface of the vessel. The throat of such fillet welds must always be less than the thickness of the skirt. Therefore, regardless of the length of the vertical leg of the weld, these fillet welds always produce a restricted path for stress and heat flow between the vessel and the skirt. This conventional form of attachment is satisfactory only if the vessels remain at substantially constant temperatures, whether ambient or elevated, for long periods of time and are not subjected to rapid cyclic temperature changes. However, if the vessels are used in processes which include a comparatively rapid cyclic swing from one to another of widely separated temperatures, the conventional form of attachment is unsatisfactory and a source of considerable trouble and expense. The cyclic operations mentioned not infrequently result in cracking of the connecting skirt weld.

The conventional delayed coking process is an example of a process having a temperature swing cycle of such severity as to render the conventional skirt attachment unsatisfactory for the vessels used. This process is a batch operation running on a cycle which varies from 24 to 48 hours. During the operating portion of the cycle the temperature of the equipment rises to about 800° F. and then falls rapidly by reason of water quenching to atmospheric. The severely cyclic nature of this operation subjects the skirt attachment weld to severe stresses. It has been found that stresses which exceed the yield point of the steel out of which the vessels are made can be developed if the axial thermal gradient exceeds 10° F. per inch. Examination of actual operating delayed coking installations indicated axial gradient values at the skirt weld in excess of 20° F. per inch as not unusual.

Cracking of the skirt weld commonly begins as small incipient cracks on the outer surface of the weld, generally at the roots between the weld beads, and as time goes on, penetrate both circumferentially and radially inwardly. Often the cracking penetrates the entire weld and vessel shell thickness so that its presence is detected by oil seepage. Cracks have been found that run entirely around the girth of the vessel and in instances, the cracks actually separated the vessel from the skirt support with the vessel sitting loosely on the skirt. The reasons for the cracking of conventional skirt welds are generally known. During the coking portion of the operating cycle a heavy heat flow exists conducting heat from the vessel wall through the skirt weld to the skirt and down the skirt

to the foundation. The resulting gradients, in the order of 10° F. and more, induce high bending moments at the skirt attachment weld. The nature of this bending is such that a tensile stress is present at the outer surface of the weld. With the simple, conventional fillet weld, the level of this calculated tensile strength is considerably in excess of 100,000 p.s.i.

Stresses in the order of 100,000 p.s.i. cannot be carried by the material out of which the coke drums, or vessels, are ordinarily fabricated. Instead, the weld metal yields a small amount to accommodate the rotation tendency of the skirt. When the vessels are brought down to ambient temperature during quenching, a heavy heat flow also exists. At this time the heat flow is from the foundation up the skirt and through the skirt weld to the vessel wall, so that the reverse plastic flow and rotation takes place, mitigated to a certain degree by the previously established locked-up stresses. With every operating cycle this high amplitude stress reversal continues. The result is fatigue cracking after a sufficient number of cycles, the cracks originating on the tensile outer face of the weld. The fatigue origin of skirt weld cracking is further indicated by the fact that in cases where the damaged weld was repaired in the conventional manner, cracking of the new repair weld proceeded with almost clockwise predictability after a period of time.

It is a principal object of this invention to provide a welded joint, and method for making it, between a vessel and its supporting skirt, such that the tendency to develop fatigue cracks in the joint over extended periods of use of the vessel is markedly reduced, if not entirely eliminated.

It is also a principal object of this invention to provide a novel welded joint, and novel method for making it, between a vessel and its supporting skirt, said vessel in use subjected to cyclic conditions that tend to the development of fatigue causing stresses in the metal joining it to the skirt, said novel joint and method such that said tendency to develop fatigue is greatly reduced, if not completely eliminated.

It is also a principal object of this invention to provide a novel skirt weld, and novel method for producing it, uniting a vessel to its supporting skirt, said vessel subjected in use to wide cyclic temperature changes, said novel weld and method such that a large area is provided for the flow of heat from the vessel to the skirt, and vice versa, whereby better heat distribution is effected and the stresses developed in the weld metal materially reduced to the end that the cracking of the weld metal due to fatigue over extended periods of use of said vessel is markedly reduced, if not completely eliminated.

It is a further principal object of this invention to provide a novel skirt weld, and novel method for making it, uniting a vessel to its supporting skirt, said vessel subjected in use to wide cyclic temperature changes, said novel weld and method such that a large area is provided for the flow of heat from the vessel to the skirt, and vice versa, and the contour of the weld is shaped to eliminate potential stress raisers, whereby the stresses developed in the weld metal are materially reduced to the end that the tendency to develop fatigue cracks in the weld metal over extended periods of use of said vessel is markedly reduced, if not completely eliminated.

The further objects, advantages, and features of my invention will become apparent from a consideration of the following detailed description thereof taken with the accompanying drawings, in which:

Fig. 1 is a front view showing a vessel supported on the skirt which connects the vessel to its foundation;

Fig. 2 is a fragmentary sectional view showing the skirt with its prepared upper edge applied to the vessel prior to welding; and

Fig. 3 is a fragmentary sectional view showing the skirt welded to the vessel.

The novel welded joint, as well as the novel method for making it are of general application and may be used wherever it is desired to provide a joint of great strength with a high factor of safety. When the parts to be united are not in use subjected to conditions so severe and cyclic as to generate stresses in the weld metal inducive to fatigue cracking thereof, the added cost of the novel joint may not be justified, and the conventional fillet welds or the equivalent are indicated. However, when the parts to be united are used under conditions so severe that fatigue producing stresses are developed in the weld metal, the joint and method of this invention are particularly applicable. The high stresses leading to fatigue cracking may result from wide cyclic temperature changes or cyclic loading changes due to pressure, or other causes.

The novel welded joint, and method for forming it, of the invention are particularly applicable to the attachment of the supporting skirts to the heavy vessels used in the materials processing and treating industries, and are especially applicable to those vessels which in use are cyclicly swung from one to another and vice versa, of widely separated temperatures. The coke drums, or vessels, used in the conventional delayed coking process are typical of the vessels to which the present invention applies. Thus by way of illustration, rather than by way of limitation, the novel joint and method of making it, of the invention will be disclosed in detail in connection with a coke drum and the attaching of a supporting skirt thereto.

The conventional delayed coking process is a batch operation which is run on a 24 to 48 hour cycle. During the coke forming portion of the operating cycle the coke drum attains a temperature of 800° F. and more. During the water quenching portion of the cycle the coke drum is brought down to ambient temperature. The quenching portion of the cycle is of comparatively short duration and takes some 8 hours and less to complete. Barring shutdowns due to failures or for repair, the cycle is repeated continuously.

Referring now to the drawing:

A coke drum **10** for carrying out the conventional delayed coking process is shown in Fig. 1. The drum **10** includes a cylindrical body section **11** whose upper end is closed by a dished head **12** and whose lower end is closed by a cone **13**. The drum **10** includes various nozzles, manholes, etc., for introducing the heated coke producing material therein, for removing of the vaporous products and formed coke therefrom, and for supplying the quenching water thereto. These manholes, nozzles, etc. have not been shown as they are conventional and are not necessary for a proper understanding of the present invention. The drum **10** in operation is vertically disposed and is mounted, as shown, on the skirt **14**. The skirt **14** is cylindrical in form and closely encircles the lower end of the cylindrical body section **11**. The bottom of the skirt **14** is connected in any suitable conventional manner to the foundation **16** which as is usual may be of masonry, concrete, or similar material. The skirt **14** is joined to the cylindrical body section **11** by the fusion weld **15**. In operative condition, the whole external surface of the drum **10** and the whole external and internal surface of the skirt **14** are covered with a thick layer of suitable insulation. The insulation has been omitted from the drawings as it is not necessary to the explanation of the invention. The skirt **14** may be attached to the drum **10** prior to the erection of the drum **10** at the site or it may be applied to the drum **10** during the erection of the vessel at the site. The coke drum **10** usually is some 70 feet high and 19 feet in diameter and will yield some 450 tons of coke per coking cycle. The coke drum **10** and the skirt are approximately one inch thick and are usually made of carbon steel.

In preparation of the welding operation, the skirt **14** has the end **17** thereof, the end that is to be its upper end when the skirt **14** is positioned on the foundation **16**, machined, flame cut, or otherwise shaped to provide the welding groove **18** shown in Fig. 2 when the skirt **14** is positioned against the vertical surface of the cylindrical body section **11**. The shaped end **17** includes an inclined chamfer **19** which ends in the curved chamfer **20**. The chamfer **18** is not carried to the outside face of the skirt **14** but rather begins at a distance *b* inwardly therefrom. It has been found in practice that if the chamfer **19** begins at the outside face of the skirt **14**, cracking may take place in the region of the juncture of the end **17** and the metal of the weld **15**, due to undercutting at the edge of the weld. By making the distance *b* about ⅛ of an inch and thus avoiding a chisel-like edge at the end **17**, cracking is effectively eliminated. Values of the distance *b* substantially in excess of ⅛ of an inch, while they too assure a crack free weld toe, are usually not desirable as they render the groove **18** too shallow. Values of *b* substantially less than ⅛ of an inch do not effectively eliminate the cracking.

In order to fully obtain the novel results of the invention, the throat of the weld **15**, in this case the distance from the vertical leg **21** at the weld **15** to the toe of the weld **15** at the end **17** measured on a line normal to the leg **21**, should be at least equal to the thickness of the skirt **14**. This can be accomplished by making the vertical weld leg **21**, shown in Fig. 3, sufficiently long. The longer the weld leg **21** relative to the thickness of the skirt **14**, the better the heat flow path. However, as the portion of the weld leg **21** forming part of the deposit in the groove **18** is made longer, the lower end of the groove **18** becomes narrower and more inaccessible. It is found as a practical matter that the best results are obtained when the chamfer **19** approaches the diagonal of a square, that is, the chamfer **19** is at an angle in the order of 45° to the horizontal. With this angle of chamfer the portion of the vertical leg **21** in the groove **18** will approach but be somewhat less than the thickness of the skirt **14**. If the chamfer **19** is carried to the inside surface of the skirt **14**, the weld groove **18** will have a steep sided, inaccessible bottom, so that the obtaining of a satisfactory joint at the root of the weld would be difficult even with very small electrodes. To provide a weld groove bottom that is readily accessible to the electrode or other welding instrumentality usually employed, the chamfer **19** terminated in the curved chamfer **20**. With the skirt **14** of a thickness in the order of 1 inch and with the chamfer **19** cut at an angle in the order of 45°, a curved chamfer **20** with a radius of ⅜ of an inch is satisfactory.

After the end **17** has been shaped, the skirt **14** and the vessel **10** are relatively positioned as indicated in Fig. 2 preparatory to welding. The welding may be carried out in any convenient manner either as an arc operation or as a gas operation. The welding is, however, preferably performed by striking an electric arc from the end of a fusible metal electrode. While the conventional flux submerged arc operation is usable, it is preferred to deposit at least the first several beads by hand welding. After the vessel **10** and the skirt **14** are positioned as indicated, the welding operation is begun, care being taken to deposit fusing weld metal into the very bottom of the groove **18** and to secure proper penetration into the metal defining the bottom of groove **18**. After this is done, further beads are deposited until the whole of groove **18** is filled. In order to improve the heat distribution and to reduce the stresses that result from the heat flow, the vertical leg **21** of the weld should be long enough to insure a throat dimension equal to the thickness of the skirt **14**. It is found that the best results commensurate with efficiency and economy are obtained if the vertical leg **21** of the weld **15** is made approximately twice the length of the

thickness of the skirt **14**. At present a vertical leg equal to 1.8 times the thickness of the skirt **14** is preferred. To achieve this result a fillet weld is deposited which extends upwardly above the weld metal which fills the original groove **18**. As indicated in Fig. 3, these further weld deposits are made in a manner to approximate the usual fillet weld contour. By this procedure a weld **15** is produced which is a groove weld combined with a fillet weld.

When the welding operation is completed, the surface of the weld **15** as well as the toe areas of the weld **15** are ground to eliminate all stress raisers which may be in the form of projections, pits, undercuttings, etc. During the grinding operation not only is the exposed surface of the weld **15** ground to provide a smooth surface but the grinding is carried out into the toe areas of the weld to obtain a smooth blending of the weld metal at said toe areas into the contiguous metal of the skirt **14** and the vessel **10**.

Although many changes can be made by those skilled in the art without departing from the scope of the invention, it is intended that all matter contained in the above description and appended claims and shown in the accompanying drawings shall be interpreted as illustrative and not limitative.

I claim:

1. A method of attaching a cylindrical supporting skirt exposed in use to ambient temperature conditions to a cylindrical body portion of a vessel adapted to be cyclically heated to elevated temperatures and cooled to temperatures approaching ambient, which comprises shaping one end of a supporting skirt to provide a generally frusto conical surface thereat with its larger diameter at the edge of said skirt at said end, disposing said skirt substantially in line with said vessel, positioning said skirt about the cylindrical body portion of a vessel with internal surface of said skirt at said end abutting external surface of said body portion and with said frusto conical surface disposed relative to external surface of said body portion to define a welding groove therebetween, said external surface of said body portion extending beyond said end, depositing fusing weld metal in said welding groove to fill said welding groove and to unite said skirt to said body portion by a fusion welded bond, depositing further weld metal on the top layers of the weld metal in said welding groove to form a fillet weld metal deposit extending along said external surface and uniting said top layers of weld metal to said body portion, and controlling the deposition of said weld metal to provide a weld metal deposit connecting said skirt and said vessel and extending along said vessel for a distance greater than the thickness of said skirt to provide a heat flow path of a capacity sufficient to prevent development of stresses in said weld metal which approach the yield point thereof.

2. A method of attaching a cylindrical supporting skirt to a cylindrical body portion of a vessel as defined in claim 1, in which the angle of the generator of said frusto conical surface relative to the longitudinal axis

of said skirt is such that the throat length of the weld metal approximates the thickness of said skirt.

3. A method of attaching a cylindrical supporting skirt to a cylindrical body portion of a vessel as defined in claim 1, in which the angle of the generator of said frusto conical surface relative to the longitudinal axis of said skirt is such that the vertical leg of the weld metal deposited in said groove approximates the thickness of said skirt.

4. A method of attaching a cylindrical portion of a supporting skirt to a cylindrical body portion of a vessel as defined in claim 1, in which the angle of the generator of said substantially frusto conical surface relative to the longitudinal axis of said skirt approximates 45° and the vertical leg of the combined deposits of weld metal approximate 1.8 times the thickness of said skirt.

5. A method of attaching a cylindrical supporting skirt to a cylindrical body portion of a vessel as defined in claim 1, in which said frusto conical surface at the smaller diameter thereof terminates in a curved surface whose curvature is sufficient to provide access to the bottom of said groove for deposition therein of fusing weld metal with complete penetration into and interfusion with the metal defining the bottom of said groove.

6. A method of attaching a cylindrical supporting skirt to a cylindrical body portion of a vessel as defined in claim 1, in which said frusto conical surface has its larger diameter smaller than the outside diameter of said cylindrical skirt to provide a flat surface approximating ⅛ of an inch in width between the external surface of said supporting skirt and said frusto conical surface.

7. A method of attaching a cylindrical supporting skirt to a cylindrical body portion of a vessel as defined in claim 1, in which the exposed surface of said deposited weld metal and the toe areas thereof are shaped to provide said exposed surface free of stress raising imperfections and to smoothly blend the toe portions of said deposited weld metal into the contiguous metal of said vessel and said skirt.

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